REpower Systems SE:
Approach to PC Round Robin

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Agenda

- Introduction
- Equivalent Wind Speed
- Excercise 1
- Excercise 3
- Summary

Introduduction

- Dfferent approaches to round robin task are possible.
- Our work resulted in a set of results

- REpower approach will be presentet
  - Exercise 1
  - Exercise 3

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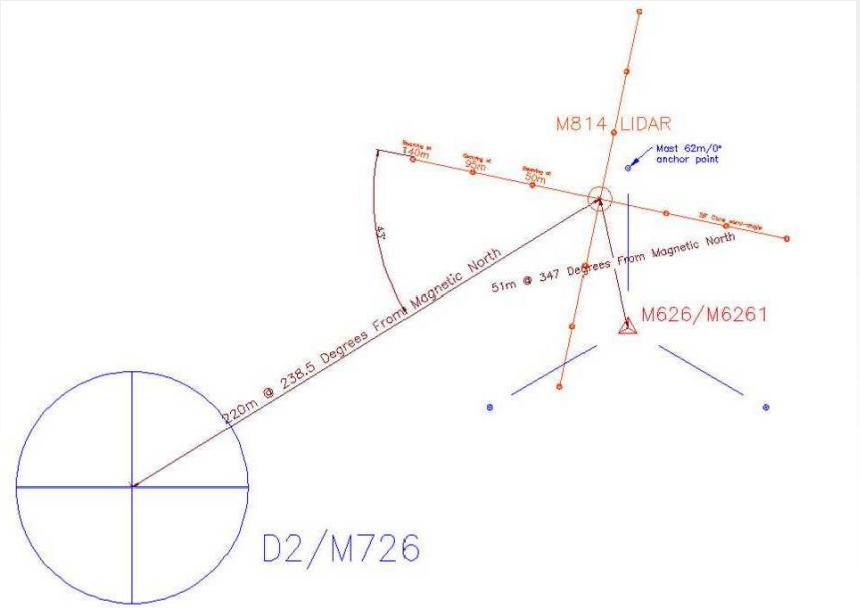
Equivalent Wind Speed

Wind data

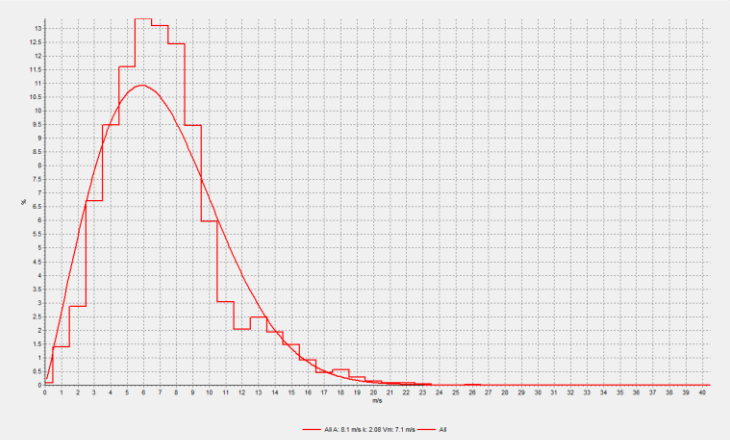
- Met mast M626 (max. measurement height 96m)
- LiDAR M814 (measurements from 52.5m to 142.5m)
- Site calibration mast M726
- Vestas V90 power curve



Equivalent Wind Speed

Evaluation of wind data

- Time series are filtered with R-script
  - Concurrent time period of M626 and M814
  - Wake affected sectors removed from both time series (no further filtering of data)
  - 5365 values remain
  - M626 at 96m is used as hub height wind speed
  - Measured wind speed: 7.24m/s
  - Weibull distribution
    - A = 8.06
    - K = 2.08
    - Weibull mean wind speed: 7.14



Equivalent Wind Speed

Calculating Equivalent wind speed

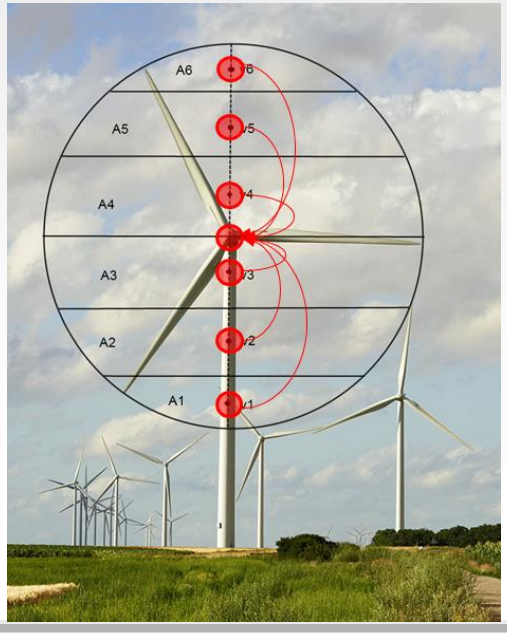
- Shear correction based on LiDAR, referenced to 96m met mast hub height wind speed
- 9 segments are used as following: 56, 66, 76, 86, 96, 106, 116, 126 and 136m (wind speeds are interpolated via shear coefficient of closest two elements.

$$v_{eq} = \left(\Sigma_{i=1}^{n} v_i^3 \frac{A_i}{A} \right)^{1/3}$$

- Additional possibility for veer correction

The following time series are calculated

1. Met Mast hub height wind speed
2. LiDAR hub height wind speed
3. LiDAR Equivalent wind speed
4. LiDAR, Met Mast Equivalent wind speed
5. LiDAR Equivalent wind speed veer corrected
6. LiDAR, Met Mast Equivalent wind speed veer corrected



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Exercise 1

AEP based on Hub Height and Equivalent Wind Speed (shear correction)

- Energy yields calculated in WindPRO based on time series (time varying AEP)
- Manual scaling to one year AEP
  - Measurement values used: 5365
  - 10-minute intervals in Full year (365.25 days): 52596
  - → scaling factor: 9.8

Time series	Energy based on time series [MWh]	AEP [MWh/year]	Ratio [%]
Met Mast	**673**	**6599**	**100.0**
LiDAR@96m	653	6401	97.0
LiDAR EqWs	656	6428	97.4
LiDAR, MM EqWS	**676**	**6629**	**100.4**
LiDAR EqWs+Veer	655	6423	97.3
LiDAR, MM EqWS+Veer	676	6623	100.4

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Exercise 3

Different Guarantee levels for Inner / Outer Range

- Use of time series from Exercise 1
  - Filter criteria for Inner Range

	Shear	TI
Hub height wind speed	0 to 0.35	6% to 20%
Equivalent wind speed	0 to 0.40	6% to 20%

  - Time series that triggers filtering can be
    - met mast
    - LiDAR
    - or also both (**AND** condition → values from both time series have to fulfill requirement for Inner Range)
    - Percentage of values in Inner Range

	Met Mast	LiDAR	Met Mast & LiDAR
hub height wind speed	61%	56%	49%
Equivalent wind speed	66%	61%	54%

Calulating Energy Yield for different Guarantee levels

- Guarantee Levels
  - Inner Range: 100%
  - Outer Range: 97%
- Energy Yield for each time stamp is multiplied with repective Guarantee level and summed up to AEP

		Guarantee Level	Guarantee Level	Guarantee Level	Guarantee Level
	Outer Range	100% of PC	97% of PC	97% of PC	97% of PC
	Inner Range	100% of PC	100% of PC	100% of PC	100% of PC
	Basis for selecting Inner (shear and TI)	--	Met Mast	Met Mast + LiDAR	LiDAR
Time series	**Filter Criteria Inner Range**	**% of base case**	**% of base case**	**% of base case**	**% of base case**
Met Mast	shear: 0 to 0.35; TI 6% to 20%	**100.0%**	**99.4%**	**99.2%**	**99.3%**
LiDAR, MM EqWS	shear: 0 to 0.4; TI 6% to 20%	**100.0%**	**99.5%**	**99.3%**	**99.4%**

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Exercise 1

- Time Series based approach was used.
- AEP was considered to depend linearily on the Energy Yield time series.

Exercise 3

- Application of Inner / Outer range criteria results in 0.5% to 0.7% reduced AEP compared to base case (100% PC for full range).
- AEP Result depends on the time series used for selection of Inner / Outer range, although differences are low.